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Fourth Industrial Revolution and Emotional Intelligence: A Conceptual and Scientometric Analysis

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ABSTRACT

A growing number of social scientists argue that we stand on the brink of a technological revolution that will drastically change the way we live, learn, and work. One of the terms adopted to name this social phenomenon is “fourth industrial revolution”. Other social scientists, in particular psychologists, have independently elaborated and discussed a concept of intelligence which is complementary, and sometimes alternative, to that measured by traditional IQ tests, namely “emotional intelligence”. In recent years, these two concepts came into contact and started interacting in scientific literature. Enhancing EI in educational programs has been seen as a possible way to prevent a predicted negative side effect of the fourth industrial revolution, namely technological unemployment. This article provides a diachronic scientometric analysis of terms and concepts. Quantitative and qualitative research tools are applied in order to reconstruct the dynamics of the Emergence, Frequency, Proximity, and Relation (EFPR dynamics) of the two concepts in the scientific literature.

KEYWORDS

Fourth industrial revolution, emotional intelligence, scientometrics, topical analysis, conceptual analysis, sociology of science

Background and Aim of the Research

There is a long research tradition in the sociology of science showing that scientific theories and discoveries are multiples, rather than singletons. As Robert K. Merton (1973) stated almost half a century ago, a great variety of evidence testifies “to the hypothesis that, once science has become institutionalized, and significant numbers are at work on scientific investigation, the same discoveries will be made independently more than once and that singletons can be conceived of as forestalled multiples” (p. 364). This awareness invites researchers (especially young researchers) to be extremely cautious when asserting the originality of their ideas or assuming that genius is the main propellant of scientific discoveries. As Merton showed, the hypothesis of multiples itself has been rediscovered many times, to the point that it can be seen as a self-exemplifying idea. In other words, science is a collective enterprise. When certified knowledge reaches a certain stage, new ideas and discoveries are “in the air”. Therefore, these ideas are subject to be independently rediscovered by many researchers. The hypertrophic growth of scientific publications, the digitalization of knowledge, and the appearance of new scientometric tools are just making more visible what was understood by the pioneers of the sociology of science long ago.

These considerations also apply to the two ideas on which this article focuses, namely “fourth industrial revolution” and “emotional intelligence”. This research aims at reconstructing the historical performance and the interplay of these two terms-and-concepts, by taking the perspective of the *sociology of science* and by using research tools offered by *scientometrics*. When Eugene Garfield (1955) paved the road to scientometrics, this field of study focused almost exclusively on citations and impact factor, and this is still the main focus of the discipline. However, scientometrics has subsequently enlarged its range of analysis to virtually anything measurable in the scientific process. Indeed, as Cantú-Ortiz (2018) specifies, “scientometrics also permits studies about research collaboration, hot research topics, research trends, patenting, funding, and other related topics” (p. 5). Here we provide an example of a scientometric analysis focused on “research topics” and “trends”.

More in detail, we will reconstruct the dynamics of the Emergence, Frequency, Proximity, and Relation (EFPR dynamics) of the key terms of our research in the scientific literature. By “Emergence” we mean the moment when the terms “fourth industrial revolution” and “emotional intelligence” made their first appearance in the history of ideas. By “Frequency” we mean both the frequency of the terms in the scientific literature and the frequency of the publications (scientific articles and books) containing the terms. We will pay attention to both the relative frequency and the absolute frequency of the items. By “Proximity” we simply mean the togetherness (or compresence) of the two terms-and-concepts in the same publication. By “Relation” we mean the theoretical or instrumental connection established by the author(s) of the publication between the two concepts. Details about research techniques will be given during the analysis.

A Conceptual and Scientometric Analysis of “Fourth Industrial Revolution”

To investigate the emergence and the relative frequency of the term “fourth industrial revolution”, we will use Google Books *Ngram Viewer*¹. Initially, we will simply extract the graphs provided by that online tool, setting the period on the interval 1930–2008. In Figure 1, one can see the relative frequency of the term.

We are well aware of all the problems and possible mistakes generated by this search tool, starting from that of “false positives”. For instance, when searching a term in periodicals, *Ngram Viewer* may identify the foundation date of the scholarly journal or the magazine, rather than that of the issue. That is why qualitative analysis is still needed when it comes to determining the actual emergence of a term-and-concept.

The item detected in 1940 is correctly located and significant. Albert Carr’s book *America’s Last Chance* uses the expression “fourth industrial revolution”. Precisely, he states that “certain writers are inclined to regard the advent of modern communications merely as an additional manifestation of the industrial revolution – as the beginnings of a new phase, a fourth industrial revolution” (Carr, 1940, pp. 141–142). He does not specify who those authors are, but he let us understand that the expression is already in use before World War II. Still, the author does not agree with the use of this formula, because it minimizes the scope of the societal change. He warns that to reject such an interpretation is not quibbling over terms. In his view, what is happening is not just a new phase of an ongoing process. It is something radically new. Therefore, Carr (1940) suggests that “the present upheaval, in fact, may well be called the aerial revolution; for its chief technology instruments are those super-terrestrial, space defying inventions, the airplane and the radio” (p. 141).

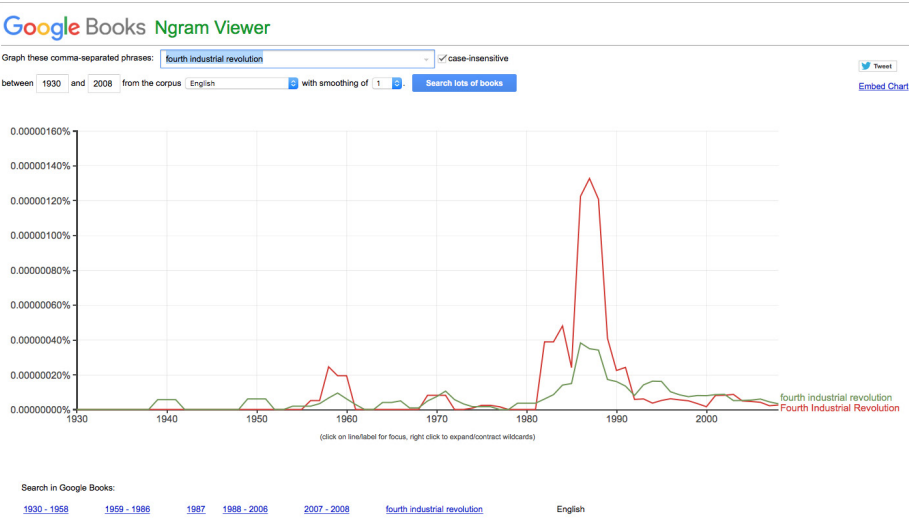


Figure 1. Google Books Ngram Viewer Graph for the Term “Fourth Industrial Revolution”, interval: 1930–2008

¹ <https://books.google.com/ngrams>

As we will see, the different phases of the industrial revolution are in general related either to the source of energy that mainly supplies the industrial system (coal, oil, electricity, nuclear power, etc.), or to the type of machines mainly used in the industrial processes (steam engine, internal combustion engine, electrical motor, computer and robot, etc.). In Carr's narrative, the accent is rather on the progressive conquest of space (terrestrial, marine, and aerial space).

In 1948, Harry Elmer Barnes publishes the book *Historical Sociology: Its Origins and Development: Theories of Social Evolution from Cave Life to Atomic Bombing*. The work appears after the Hiroshima and Nagasaki bombing and, not surprisingly, the emphasis goes on the new energy source. However, quite interestingly, the technological breakthrough is still also related to space occupation. These are his words: "With the coming of intra-atomic energy and supersonic stratosphere aviation we face an even more staggering fourth Industrial Revolution" (Barnes, 1948, p. 145).

In 1955, Harold Ordway Rugg and William Withers use again the expression "fourth industrial revolution" in the book *Social Foundations of Education*. In their narrative, the breakthrough is temporally located after World War II and is related to the new energy source and machine typology, while the reference to the occupation of the aerial space drops out of the definition. This is the fragment of the book relevant to our study: "After World War II, we entered a fourth industrial revolution, with great advancement in electronics and in the world-shaping development of atomic power. The world entered a creative age in which nature could be greatly transformed, both as to substance and power" (Rugg & Withers, 1955, p. 45).

On April 12th, 1961, Yuri Gagarin completed one Earth orbit on the capsule *Vostok* and became the first human to journey into outer space. NASA also prepares for space exploration. The space factor is back as a determinant of the new technological phase. Colonel Carl A. Ousley, in his work *National Security in Outer Space* (1962, p. 40), writes:

The research phase of the American economy is having a phenomenal growth as a result of space exploration. One recent study considers research as the fourth major industrial revolution in American industry following steam mechanization, steel, and electrical-and-internal combustion engines. The fourth industrial revolution, ours, is unique in the number of people working on it, its complexity, and its power to push the economy at a rate previously impossible.

Here the emphasis is on research and space exploration. The idea is that science is the very propellant of the fourth industrial revolution. A few years later, a generic emphasis on science is found also in Asoka Mehta's *Economic Planning for India*. The interesting aspect of this publication is that the author is not sure which phase of the revolution we are experiencing. He writes that "today, science and technology has given us enormous powers. We are witnessing a revolution in agriculture and perhaps, the third or fourth industrial revolution with a series of breathtaking advances in science and technology" (Mehta, 1970, p. 104). Third or Fourth? This definitional uncertainty is typical of the field. For instance, according to Rifkin (2011), the third

industrial revolution starts in the 21st century. He indicates the year 2008 (the financial crisis) as the peak of the second industrial revolution and the beginning of the third one. In this perspective, the fourth industrial revolution is a topic left to science fiction writers. But let us go back to the 1970s.

In 1977, French sociologist Jacques Ellul publishes *Le Système Technicien*. The English translation appears three years later. Ellul discusses also the criteria we use to distinguish the different stages of industrial change. He underlines that, generally, the different stages are associated with energy production: “Observers thus speak of the ‘first industrial revolution’, characterized by the use of coal as a power source, and by the machines built to use coal. Then came a second industrial revolution, characterized by electricity. The third one causes some wavering: the use of atomic energy” (Ellul, 1980, p. 25). However, in the 1970s, the fourth industrial revolution is rather associated with the new electronic machines entering the production process. The French scholar notices that “for several years now, people have been speaking of a fourth industrial revolution: the one launched by the computer. It is obvious that we are now switching gears, for this is no longer a change or advance in power sources” (Ibid.). Quite interestingly, Ellul put emphasis on the fact that this technological change renders the human force obsolete, because “the dominant factor is no longer a growth of potential or exploited energy, but rather an apparatus of organization, information, memorization, and preparation for decision-making, to replace man in a huge number of intellectual operations” (Ibid.).

What is rather noncontroversial at this stage of the analysis is that the fourth wave of technological innovation started after World War II. For instance, the same periodization is found in Thomas M. Kando’s *Leisure and Popular Culture in Transition* (1980), where we read that “the fourth industrial revolution is the label customarily attached to the dramatic increase in productivity that has taken place in the United States and elsewhere in the Western world since the Second World War” (p. 93).

Italian economist Paolo Sylos-Labini in an article published in 1984 (*New Aspects of Cyclical Development of the Economy*), put together the three different criteria used to build a periodization – machine typology, space occupation, and energy source – and stresses that there is consensus on this picture. Precisely, he writes that “it is widely held that we are now living in the fourth industrial revolution which is dominated by electronics, air transportation and atomic energy; indeed, it is argued that we have for some years been in the declining phase of the fourth Kondratieff cycle” (Sylos-Labini, 1984, p. 17).

In the 1980s, Walt Whitman Rostow is one of the most engaged scholars on the definition of this concept. In a speech delivered at the Congress of the United States of America, the economist explains that the fourth industrial revolution is a process that must be nurtured: “The character of the technologies embraced in what I have called the Fourth Industrial Revolution makes it possible for a high proportion of the relevant R&D to be carried forward by the private sector”; however, the government has to guarantee the conditions for the growth, by creating an environment of low real interest rates and keeping inflation under control. If this is assured, “we can expect innovation to proceed rapidly, by normal market processes, in exploitation of the microchip in all

its ramified applications, new communications methods, the insights of genetics, the robot and laser, and new industrial materials” (Rostow, 1983, p. 149).

As we can see, several technologies are included in the definition. Now, the emphasis does not go only on microelectronics, but also on genetic engineering. In the book *Theorists of Economic Growth from David Hume to the Present: With a Perspective on the Next Century*, Rostow presents an historical picture of the industrial revolution and establishes the beginning of its fourth phase in the mid-1970s.

In short, while agreeing substantially with the emphasis – from Adam Smith to Nathan Rosenberg – on the importance of incremental technological change, I would also reaffirm the legitimacy of Schumpeter’s dramatization of the three great industrial revolutions on which he focused in *Business Cycles*: that of the 1780s, with its convergence of the new textile machinery, Watt’s steam engine, and Cort’s method of fabricating good iron with coke; the railroad revolution, starting modestly in the 1830s but helping induce before long the steel revolution to overcome the high obsolescence rate of iron rails; and the breakthroughs in electricity, chemicals, and the internal combustion engine round about the turn of the century. The fourth, asserting itself from, say, the mid-1970s, after long incubation, embraces four large fields: microelectronics; genetic engineering; the development of new industrial materials (e.g., ceramics, optical fibers, a new round of plastics); and the laser (Rostow, 1992, p. 456).

If the fourth industrial revolution starts in the mid-1970s, of which revolution Carr and others were talking about by referring to the post-war period? Rostow recognizes that there has been a long incubation to this process. In the same book, we read that the author is “inclined to regard the leading sectors of the postwar boom (including plastics, synthetic fibers, and television) as the rounding out of the Third Industrial Revolution” (Rostow, 1992, p. 673). In other words, he resolutely underlines the difference between electronics (vacuum tubes, transistors) and microelectronics (integrated circuits, microchips): “I would identify micro-electronics, genetic engineering, new synthetic materials, and the laser as the Fourth Wave, dated from the mid-1970s” (Ibid.).

In the same year, Devendra Thakur (1992) states that “the scope for India to exploit the skill revolution or the fourth industrial revolution which substitutes skilled labour for both capital and unskilled labour appears large and promising” (p. 296). One year later, Hong-Hwa Lee clarifies that, if there is a consensus about the fact that a major change in the economy is happening, there is no consensus about the name to be given to that change. Indeed, “there are different terminologies used to describe the current explosion of new technologies – ‘the fourth industrial revolution’, ‘second industrial divide’, ‘the third wave’, ‘the age of smart machine’, and so on” (Lee, 1993, p. 268).

To be precise, there is no consensus also about periodization. In his Ph.D. dissertation about Japanese economic policy, Bai Gao (1994) reminds that “the Japanese economists argued in the mid-1950s that *now* [our emphasis] the fourth industrial revolution was coming, stimulated by the use of atomic power and automation” (p. 280).

According to Zoltan Barany and Ivan Volgyes (1995), this disrupting technological change had to happen before 1989, since one of the reasons why communism failed in Eastern Europe was that “the Communist states missed out on the fourth industrial revolution – the technological revolution – and their economies were doomed to remain largely technologically backward and outmoded” (p. 7).

Writing in the early 1990s, Ira W. Lieberman points out that this breakthrough happened before 1989, but not necessarily in the 1950s or the 1970s. Indeed, he talks about the emergence in the 1980s of “what some analysts are calling the fourth industrial revolution”; he specifies that this industrial revolution is driven by information technology and “involves non-smoke-stack industries such as telecommunications, computers, microelectronics, robotics, fiber optics and advanced and composite materials” (Lieberman, 1993, p. 10).

However, computers, robots, and satellites completely disappear from the narrative of Gilbert Mudenda, who subdivides the phases of economic development by placing some emphasis also on geographical areas:

The first industrial revolution (1780–1840) was based in the United Kingdom, and its key achievements were the steam engine, the textile industry, and mechanical engineering. The second industrial revolution (1840–1900) was based in Europe (England, France, and Germany), and its key achievements were railways and the steel industry. The third industrial revolution (1900–1950) was based in the United States, and its key achievements were the electric engine and industries manufacturing heavy chemicals, motor cars, and consumer durables. The current phase, the fourth industrial revolution (1950–2000), is based in the Pacific Basin (Japan and California), and its key industries are synthetics and organic (petroleum) chemicals (Mudenda, 1995, p. 85).

One year later, political scientist Donald M. Snow affirms that the current cutting edge is the information-based revolution and underlines the appearance of more sophisticated goods and services; however, he also admits that “the contours of a fourth industrial revolution have not yet appeared clearly on the horizon” (Snow, 1996, p. 14). Notably, this American author is not just assuming that what happens in the USA is happening, or will necessarily happen everywhere. If there are countries that start experiencing the effects of the fourth industrial revolution, there are other countries that are still struggling with the second or the third. And he also reminds us that there are scholars that call “postindustrial” those economies and societies in which the Tertiary sector is prevalent on the Primary and the Secondary sectors, in terms of percentage of GNP generated or number of employees.

In the mid-1990s, however, the emphasis on information technology seems to be prevalent. Indeed, George Kozmetsky and Piyu Yue (1997) distinguish the third industrial revolution, which is “based on inventions and innovations in the areas of chemicals, electricity, petroleum, and the internal combustion engine”, from the fourth industrial revolution, in which “information technology is playing a similar pivotal role in changing the way of life for individuals and for corporations”

(p. 5). They also specify that “information technology is defined as the use of computers and telecommunications to process, manipulate, create, and distribute information,” and they make it clear that while the third industrial revolution “helped the United States surge into its position as the world’s primary industrial power in the beginning of the 20th century”, the fourth will have a global scope (Kozmetsky & Yue, 1997, p. 5). They assume that the USA will still have a central role for at least the first half of the 21st century, but this leadership will be challenged by traditional competitors (France, Germany, Great Britain, Italy, and Japan) and by the new emerging economies (China, India, Singapore, South Korea, and other Second and Third-World countries).

Education expert Evans Clinchy (1999) notices that the crucial inventions that have changed our lives emerged from the scientific/military/political alliance, and not from the disconnected scholarly world. The industrial-military complex also shaped “our present fourth Industrial Revolution based upon the digital computer and modern communications technology” (Clinchy, 1999, p. 78). That is why, according to Clinchy, a profound reform of american education is needed.

Communications technology is only one of the many aspects of the fourth industrial revolution according to Dike N. Kalu, who proposes a comparison between technologically advanced countries and Nigeria. Having a background in biology, this African scientist points out that “the United States and the western world have already experienced their second and third industrial revolutions and are currently in the midst of a fourth industrial revolution, characterised mainly by improved communication, increased use of molecular biology techniques and widespread use of food supplements” (Kalu, 2003, p. 54).

One more record signaled by *Ngram Viewer* is the book chapter *Privatization in the Transition Economies* by Ira W. Lieberman, an author that we have already encountered in the early 1990s. In 2008, the American economist has not changed his mind concerning the periodization and the main aspects of the fourth industrial revolution. According to him, the breakthrough is mainly (but not uniquely) driven by information-based technologies and temporally located in the 1980s (Lieberman, 2008, p. 4).

The scan of all books and periodicals is a work-in-progress and, therefore, the *Ngram Viewer* database is largely incomplete. There are no data after the year 2008. Besides, this tool provides the relative frequency of the term, but not its absolute frequency, nor the absolute number of publications containing the term. To collect the missing information concerning the decade 2009–2018, we will perform a search on *Google Scholar*. We will use the retrieved data to reconstruct the annual distribution of the publications containing the term “fourth industrial revolution” (and possible equivalent terms). On this interval, we will work with absolute numbers of publications, rather than relative frequencies of term occurrences. Graphs and diagrams will be crafted in *Microsoft Excel*.

Google Scholar is notoriously less selective than such international citation databases as *Scopus* or *Web of Science*. It also includes works that are not strictly scientific. However, by working on a larger number of items, this tool provides a good

measure of the penetration of ideas in the scientific community and in the grey area that surrounds it. Data extracted from *Scopus* and *Web of Science* are of particular significance for academic bureaucracy. Indeed, they are often used to assign research funds or to structure careers. However, the sociology of science considers the propagation and reputation of ideas more relevant than their inner validity (which is a matter left to philosophers and scientists). As a consequence, data extracted from a more receptive database such a *Google Scholar* seems to be of major significance from a sociological point of view.

The results of our first search wave are presented in Figure 2. As on can see, in the last decade, the growth of scientific publications containing the term “fourth industrial revolution” is an approximately exponential trend.

Those included in the graph are absolute numbers of publications. However, as Figure 3 displays, the global number of publications in the first half of the decade is rather constant (around for million per year). In the second half, it shows more variations, but no clear pattern is visible. In the year 2008, the total number of items reaches 5 million. This means that the performance of the term during the last decade cannot be explained on the basis of the trend of the total number of publications. For instance, the total number of publications decreases from 2015 to 2016, while the number of books and articles including the term “fourth industrial revolution” grows.



Figure 2. 10-year Distribution Graph of Publications Including the Term “Fourth Industrial Revolution”

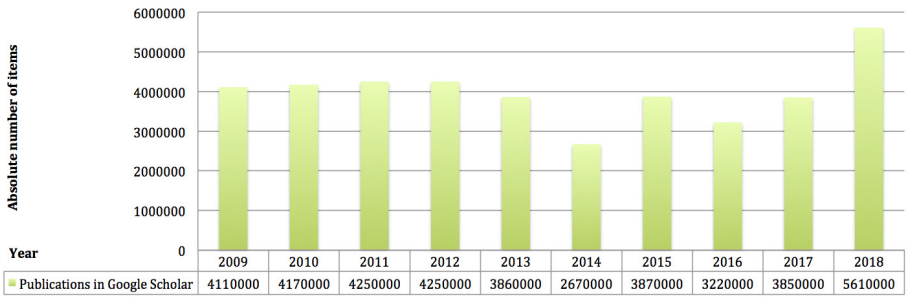


Figure 3. 10-year Trend of the Publications Detected by Google Scholar

As the *Ngram Viewer* graph [Figure 1] shows, the best performance of the term “fourth industrial revolution” is rather located in the second half of the 1980s. In the first decade of the third millennium, the relative frequency of the term goes down to a minimum. On the contrary, in the second decade of the millennium, we can observe a renaissance of this term-and-concept. Why has the trend changed? The game-changer seems to be the World Economic Forum (WEF) founded and chaired by German economist Klaus Schwab, and annually held in Davos.

In particular, a WEF report published in January 2016 (*The Future of Jobs. Employment, Skills and Workforce Strategy for the Fourth Industrial Revolution*) seems to have played a major role in the current success of the term. In the Preface of the report, Samans and Schwab (2016) writes that “developments in genetics, artificial intelligence, robotics, nanotechnology, 3D printing and biotechnology, to name just a few, are all building on and amplifying one another”, and the consequence of all this will be “a revolution more comprehensive and all-encompassing than anything we have ever seen” (p. v).

If in Rifkin’s opinion we are at the cusp of the third industrial revolution, according to Schwab the third phase of technological innovation is a historically concluded phenomenon. It started in the 1970s, with the massive entrance of computers and industrial robots into the workplace, and is ending now. Currently, we rather observe the very beginning of the fourth industrial revolution (Schwab, 2017, 2018a).

Schwab’s four-phases periodization is now gaining major consensus and it is developed by other social scientists in new directions. In this last representation, each phase of the industrial revolution is associated with the emergence of a new type of *industry*. Industry 1.0 starts in 1784 with the appearance of the first mechanical loom; Industry 2.0 starts in 1870 with the appearance of the first assembly line; Industry 3.0 starts in 1969 with the appearance of the first programmable logic controller; and, finally, Industry 4.0 starts “today” – to say the beginning of the 21st century – with the appearance of smarter machines, devices, sensors, capable of connecting and communicating with each other and with people, via the Internet of Things (IoT) or the Internet of People (IoP). However, the other criteria used to build a periodization (source of energy, geographical location, space occupation) did not disappear from the scientific discourse. The World Economic Forum is now paying much attention also to renewable sources of energy. The fourth industrial revolution is explicitly associated with renewable sources, such as wind turbines, solar panels, advanced storage devices, and hydrogen (Nasman et al., 2017; Zhai, 2019). The global scope of the fourth industrial revolution can hardly be contested, as Schwab (2018b) confirmed by defining the term “Globalization 4.0”. Finally, some scholars relate the fourth industrial revolution with the expansion of automated industries on other celestial bodies, for instance, to perform asteroid mining operations (Campa, Szocik & Braddock, 2019).

To sum up, currently, the fourth industrial revolution can be basically identified as the era of “smart industries”, powered by “renewable sources of energy”, with a “global geographical scope”, a temporal location in the “21st century”, and a prospect to expand industrial activities in “outer space”. Table 1 provides a synoptic frame of the industrial revolution phases as they are generally understood now.

Table 1. Synoptic Frame of Industrial Revolution Phases

	Temporal location	Space occupation	Machine type	Geographical Location	Energy Source
1 st Industrial Revolution	18 th Century (from 1784 to 1870)	Terrestrial (railways, steam locomotive)	Mechanization, Steam engine, Textile industry	England	Water power, Coal
2 nd Industrial Revolution	19 th Century (from 1870 to 1969)	Marine (steamship, transatlantic crossing, submarines)	Internal Combustion Engine, Electric Motor, Assembly Line	United Kingdom, Western Europe, Russia USA, Japan	Oil Electricity
3 rd Industrial Revolution	20 th Century (from 1969 to 2000)	Aerial (airplane, radio, television, satellites)	Computer, Automation, Laser, Internet, Mobile phones	Europe, America, Asia	Atomic energy
4 th Industrial Revolution	21 st Century (from 2000 onward)	Outer Space (spacecraft, asteroid mining)	Internet of things, Cybersystems, Smart industry, Advanced robotics, Artificial Intelligence	Earth	Solar panels, Wind turbines, Storage devices, Hydrogen economy

A Conceptual and Scientometric Analysis of “Emotional Intelligence”

Once again, let us start from the *Ngram Viewer* graph, by searching the term “emotional intelligence”. As one can see from Figure 4, it is a relatively new term. It emerged in the mid-1990s and, after a steady growth, it experienced a peak in the mid-2000s.

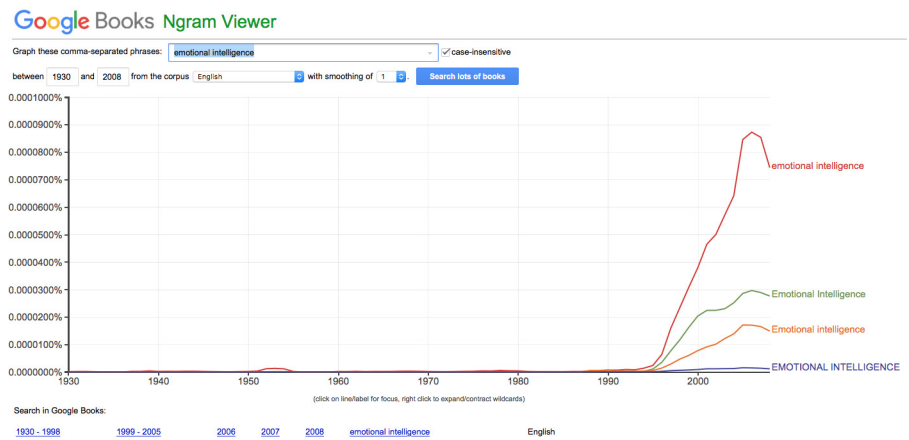


Figure 4. Google Books Ngram Viewer Graph of “Emotional Intelligence”, interval 1930–2008

This does not mean that the concept is novel. Back in 1964, Michael Beldoch published a work entitled *Sensitivity to Expression of Emotional Meaning in Three Modes of Communication*, which investigates the interrelationships among abilities to identify non-verbal emotional expressions in three modes of communication: vocal, musical and graphic. The work was then republished as a chapter in the book *Social Encounters*, edited by Michael Argyle (1973). More in detail, Beldoch (1973, p. 124) focuses on the “interrelationships among abilities to identify emotional meanings expressed in different media, and the relationship of self-reported personality characteristics as well as various background factors to the several measures of emotional sensitivity”.

The expression “emotional intelligence” emerges in 1990 when Peter Salovey and John Mayer publish an article under this title in the journal *Imagination, Cognition, and Personality*. As they make it clear in the abstract, the article “presents a framework for *emotional intelligence*, a set of skills hypothesized to contribute to the accurate appraisal and expression of emotion in oneself and in others, the effective regulation of emotion in self and others, and the use of feelings to motivate, plan, and achieve in one’s life” (Salovey & Mayer, 1990, p. 185).

An interesting aspect of this seminal work is that it is mainly based on a literature review. It is a theoretical work, more than empirical research. The authors analyze the debate about the adaptive versus maladaptive qualities of emotion and review the scientific literature on intelligence. They pay particular attention to “social intelligence”, an already existing concept, and to the role that emotions play in the traditional conceptions of intelligence. Based on the information collected, Salovey and Mayer (1990, p. 185) describe “a framework for integrating the research on emotion-related skills” and, then, “review the components of emotional intelligence”. To sum up, the article forges the concept of emotional intelligence starting from the already existing research and suggests new directions for further investigation.

Still, as one can see from the graph, this article does not receive much attention in the first five years after its publication. Indeed, as regards this concept, the game-changer is 1995 Daniel Goleman’s book *Emotional Intelligence: Why it can matter more than IQ*.

Goleman is a scientific journalist and his book belongs to popular science. Still, the author is well informed about the research going on in psychological laboratories, and also shows a good knowledge of the classics of philosophy. His idea of emotional intelligence is based on a synthesis of current research. In particular, his focus is on the brain architecture underlying emotion and rationality. The author starts from a simple observation: contrarily to all expectations, people with a higher IQ often perform worse than people with a more modest IQ level, both in professional and everyday life. In his words:

IQ offers little to explain the different destinies of people with roughly equal promises, schooling, and opportunity. When ninety-five Harvard students from the classes of the 1940s – a time when people with a wider spread of IQ were at Ivy League schools than is presently the case – were followed

into middle age, the men with the highest test scores in college were not particularly successful compared to their lower-scoring peers in terms of salary, productivity, or status in their field. Nor did they have the greatest life satisfaction, nor the most happiness with friendships, family, and romantic relationships (Goleman, 1995, p. 35).

The main idea that follows from this observation is that other factors must be at work making for the success of people with lower IQ. In other words, there must be a different way to be smart. The term chosen to indicate this different type of smartness is “emotional intelligence”. According to Goleman, emotional intelligence is related to many psychological features, such as impulse control, self-awareness, zeal, persistence, empathy, self-motivation, social deftness, character, self-discipline, altruism, and compassion. To excel in real life, one needs these qualities no less – and perhaps even more – than logical intelligence. Intimate relationships are important factors of success both in the workplace and in sentimental life.

According to Goleman, emotional intelligence is not fully genetically inherited. Since it is not fixed at birth, guidance can be provided as to how teachers and parents can nurture and strengthen this quality in children.

Goleman’s book rapidly became a bestseller. As a consequence, many other authors started riding the wave. Subsequent publications focus in particular on the guidance to be provided to teachers and parents. For instance, one year later the appearance of Goleman’s book, Dianne Schilling publishes a guide entitled *50 Activities for Teaching Emotional Intelligence*, which emphasizes that different types of intelligence should be nurtured together. In her words, “rational intelligence cannot perform well without emotional intelligence, and emotional intelligence benefits from the cool cognitive judgments of the rational mind. When the two perform together smoothly and efficiently, emotional intelligence rises and so does intellectual ability” (Schilling, 1996, p. 3).

Another guide is published in 1997 by Kerry David Carson, Paula Phillips Carson, and Joyce Schouest Phillips. The three authors quote the work by Daniel Goleman. They refer to him as a renowned social psychologist who indicates that success and failure in everyday life and in the workplace could depend more from “emotional intelligence” than from IQ. They summarize his theory as follows: “He describes emotional intelligence as a multidimensional construct consisting of five factors: 1. mood regulation; 2. self-motivation; 3. self-awareness; 4. empathetic response; 5. interpersonal skill” (Carson, Phillips & Schouest, 1997, p. 150).

At this point, Salovey and Mayer come back into play to claim their role in the creation of the idea. In 1997, they sign the first chapter of a collective work entitled *Emotional Development and Emotional Intelligence: Educational Implications*, edited by Peter Salovey and David J. Sluyter. In the synopsis of the volume, the editors recall that experts in education and psychology have long viewed feeling and thinking as polar opposites. On one pole there is passion, on the opposite pole lies reason. They also underline that emotion has often been labeled as immature, haphazard, and chaotic. However, everything changed when Salovey and Mayer

introduced the concept of emotional intelligence. This notion challenges the belief that intellectual processes are unrelated to the management of emotion-laden information. Afterward, innovative schools have focused more carefully on emotional intelligence, emotional literacy, or emotional competence, by developing courses aimed at enhancing these abilities. It is important to notice that the editorial project openly recognizes Goleman's role in popularizing the idea. Indeed, the science journalist is invited to write the foreword to the book. In their contribution, Salovey and Mayer (1997, p. 22) explain that "emotional intelligence is the ability to perceive emotions, to access and generate emotions so as to assist thought, to understand emotions and emotional meanings, and to reflectively regulate emotions so as to promote both better emotion and thought". The authors conclude that we are just at the beginning of the learning curve about this subject.

In 1998, there is an explosion of publications on emotional intelligence. Daniel Goleman tries to replicate the success of his first book on the topic by publishing *Working with Emotional Intelligence*, David Ryback publishes *Putting Emotional Intelligence to Work: Successful Leadership Is More Than IQ*, and Seymour Epstein comes out with *Constructive Thinking: The Key to Emotional Intelligence*.

Other guides are printed in the following years. For instance, *50 Activities for Developing Emotional Intelligence* by Adele B. Lynn (2000), who reports that "quantifiable data on performance in a myriad of industries and organizations has resulted in a body of study called emotional intelligence", and adds that "these years of study have named and identified the 'intangibles' that predict success in the workplace" (p. 1). Her guide is supposed to help nurturing these "intangibles", and in particular emotional intelligence, which "explains why despite equal intellectual capacity, training, or experience, some people excel while others of the same caliber lag behind" (Ibid.).

It is not difficult to explain the success of these publications in a highly competitive society such as the United States of America. They give hope to individuals that, after modest performances in schools and universities, feel hopeless. The message is simple and reassuring: the problem is not you; the problem is the educational system that focuses on the wrong type of intelligence. Besides, school and work are not everything that matters. Interpersonal relationships, love, friendships, family ties, etc., are also fundamental in making a person successful.

While Salovey seems more interested in developing the concept in relation to business, Mayer rather focuses on everyday life. In 2001, together with Joseph Ciarrochi and Joseph P. Forgas, Mayer edits a book entitled *Emotional Intelligence in Everyday Life: A Scientific Inquiry*. As one can see, the emphasis is once again on the scientific character of these studies, to differentiate them from Goleman's seminal work and the many guides published in the following years. In his introduction, "A Field Guide to Emotional Intelligence", Mayer (2001) also traces a brief history of the concept, by stressing once again the importance of his 1990 contribution, crafted together with Salovey.

Also in 2001, Gwen Doty publishes *Fostering Emotional Intelligence in K-8 Students: Simple Strategies and Ready-to-Use Activities*. The book aims

to help teachers to assess emotional intelligence based on their observation. According to Doty (2001), no assessment should be given “until after the school year is underway, when teachers have gained an ample understanding of their students” (p. 143). Besides, each student should be assessed on each of the five emotional intelligence components elaborated by Goleman. Another book aimed at fostering emotional intelligence in children at school is crafted by Margie Blaz, Avi Bitton and Rebecca Reyes. In *Developing Your Child's Emotional Intelligence: Ten Steps to Self Control from Birth to Age Three*, the authors focus “on how and when to teach the basic emotional lessons that will empower your child with self-control and emotional intelligence” (Blaz, Bitton & Reyes, 2003, p. ii).

Emotional intelligence is crucial not only to succeed in business and love relationships but also in higher education. This point is stressed by Darwin B. Nelson and Gary R. Low in their 2003 book *Emotional Intelligence: Achieving Academic and Career Excellence in College and in Life*. An improved second edition has been published in 2010. As the authors clarify, the book “provides students with theory-based and research-derived information about how the brain works in regard to emotional intelligence and practical emotional learning” (Nelson & Low, 2010, p. xvi).

In 2007, Mayer and Salovey, together with Marc A. Brackett, edit *Emotional Intelligence: Key Readings on the Mayer and Salovey Model*. It is a reader including the most important articles and essays published by Mayer, Salovey and their collaborators on the topic of emotional intelligence.

Finally, we want to mention the 2008 article “Emotional Intelligence: New Ability or Eclectic Traits?” published once again by Mayer and Salovey, this time in co-authorship with David R. Caruso, in the journal *American Psychologist*. Here, the authors provide the following definition of emotional intelligence:

Emotional Intelligence includes the ability to engage in sophisticated information processing about one's own and others' emotions and the ability to use this information as a guide to thinking and behavior. That is, individuals high in emotional intelligence pay attention to, use, understand, and manage emotions, and these skills serve adaptive functions that potentially benefit themselves and others (Mayer, Salovey & Caruso, 2008, p. 503).

To sum up, Mayer and Salovey propose a developmental model of emotional intelligence from childhood to adulthood based on sixteen steps. This process generates four different abilities. According to these psychologists, an emotionally intelligent person can perceive emotions in oneself and others accurately; use emotions to facilitate thinking; understand emotions, emotional language and the signals conveyed by emotions; and eventually, manage emotions to attain specific goals.

In the following decade – precisely in the interval 2009–2018 – publications on emotional intelligence show a constant growth (see Figure 5).

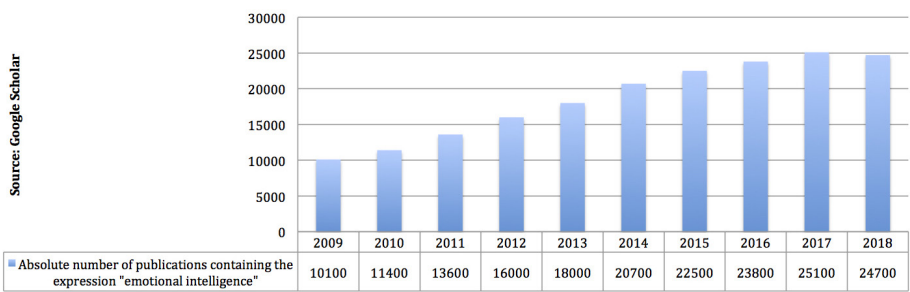


Figure 5. 10-year Distribution Graph of Publications Including the Term “Emotional Intelligence”

There seem to be a flexion in 2008, but it must be taken into account the fact that it takes time for authors to register their publications in online repositories and for Google Scholar to detect them. We surmise that the number of 2008 publications will grow shortly.

State of Proximity and Theoretical Relation

It is time to verify the state of proximity and the theoretical relations between our two terms-and-concepts. Let us start with the first problem, which is inherently quantitative. As one can see in Figure 6, the growth of publications including both terms is really impressive. It shows than more and more scholars are now relating the two concepts, even though they were born in two different scientific disciplines.

Empirical data show that the major change is located in the year 2016. Also in this case, there are all reasons to think that the game-changer is the report *The Future of Jobs Employment, Skills and Workforce Strategy for the Fourth Industrial Revolution*, published by the World Economic Forum in January 2016. Indeed, in Samans and Schwab’s Preface, we do not only learn that humanity is at the starting point of a fourth industrial revolution. There is more than this. When it comes to make clear what is needed to turn the societal change into an opportunity, rather than a disaster, the authors prophesize that “overall, social skills – such as persuasion, emotional

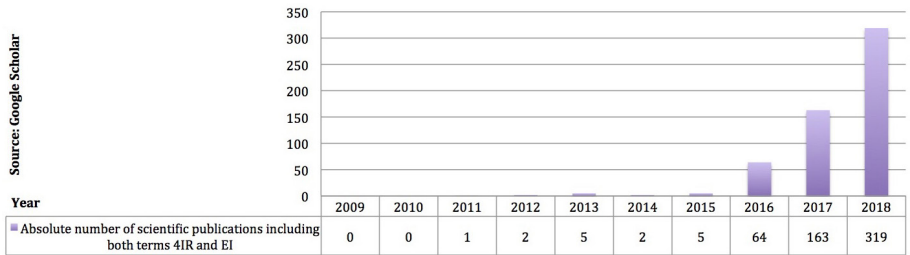


Figure 6. 10-year Trend of the State of Proximity between “Fourth Industrial Revolution” and “Emotional Intelligence”

intelligence and teaching others – will be in higher demand across industries than narrow technical skills, such as programming or equipment operation and control” (Samans & Schwab’s, 2016, p. 22).

The report lists the following ten skills as crucial for employment by 2020: (1) Complex Problem Solving; (2) Critical Thinking; (3) Creativity; (4) People Management; (5) Coordinating with Others; (6) Emotional Intelligence; (7) Judgment and Decision Making; (8) Service Orientation; (9) Negotiation; (10) Cognitive Flexibility. Besides, it provides the following definition of emotional intelligence: “Being aware of others’ reactions and understanding why they react as they do” (WEF, 2016, p. 53).

Given the influential role of the Davos annual meeting, it is not surprising to find in the following years many more publications presenting the nurturing of emotional intelligence as a possible solution to the unwanted side effects of the fourth industrial revolution, and in particular technological unemployment. If we include in the count the year 2019, we obtain almost one thousand publications (921, to be precise), which include both concepts. Here we will provide just six examples, two per year, on how the concepts are related.

In 2016, by focusing on “entrepreneurial intelligence”, J.H. (Cobus) Oosthuizen expands Schwab’s four-type intelligence proposition in order to address the challenges of the new technological phase. First of all, he subscribes to the narrative that humanity finds itself at the dawn of the fourth industrial revolution and that the incoming societal change presents features never experienced before in history. There were radical transformations also in the past, but not with the velocity, breadth, depth, and systems impact of the current one. Oosthuizen (2016) states that “Schwab propagates a 4-type intelligence proposition (contextual-, emotional-, inspired-, and physical intelligence) to be nurtured and applied so as to adapt, shape and harness the potential of disruption” (p. 370). According to Oosthuizen, Schwab’s proposition lacks a disposition type of intelligence, namely “entrepreneurial intelligence”, which should be added to the model.

In the same year, the Finnish Minister of Finance Alexander Stubb publishes a document entitled *For an Optimistic Revolution*. The author emphasizes the inevitability of the new technological breakthrough, assumes that every challenge is an opportunity, and professes optimism about the outcomes of the process. Stubb also underlines that those feeling pessimistic or unprepared about the societal transformation will not change the course of history by simply complaining about technology. They like it or not, the fourth industrial revolution will happen, and actually it “appears to be upon us”. This is the way he describes the upcoming epochal event:

With the advent of 5G mobile Internet, smaller and more powerful sensors, artificial intelligence and machine learning, this revolution will be as transformational, if not more so, as anything mankind has experienced before. It will change the way we live, work and relate to each other. Artificial intelligence, robotics, the Internet of Things, 3D printing, nanotechnology, biotechnology, renewable energy, and quantum computing: such advances are transforming the world faster than we realise. Occupations which only a few short years ago

appeared safe bets, such as those of bus drivers and lorry drivers, may soon go the way of the horse, thanks to artificial intelligence now being applied to self-driving vehicles (Stubb, 2016, p. 21).

Does he also relate the fourth industrial revolution with emotional intelligence? Yes, he does. Indeed, he insists that “the more technology advances, the more emotional intelligence and empathy come to the fore” (Stubb, 2016, p. 21).

He concludes his speech with an encouraging exclamation: “Welcome to the future”.

In 2017, Chris Wilson, Peter Lennox, Gareth Hughes and Michael Brown craft the chapter “How to develop creative capacity for the fourth industrial revolution”. They state that “universities have never been more focused on ensuring that graduates are ‘employable’”, and add that “in the midst of the fourth industrial revolution, numerous studies highlight the potential significance and value of creativity, problem-solving and critical thinking, for successful navigation of the complexities of the future” (Wilson et al., 2017, p. 241). Their declared goal is to elaborate a synthesis of related fields of research, with the aim of constructing a framework for the improvement of creativity. In their synthesis, the concept of emotional intelligence also finds place, and the explicit source of the idea is the World Economic Forum’s 2016 report *The Future of Jobs* (WEF, 2016). The four scholars conclude that a reform of certain aspects of pedagogical practice is needed.

In the same year, Bo Xing and Tshilidzi Marwala discuss the relations between education, fourth industrial revolution and emotional intelligence in the article “Implications of the Fourth Industrial Age for Higher Education”, which appeared in the journal *The Thinker*. The authors underline that “the fourth industrial revolution is powered by artificial intelligence and it will transform the needs of the workplace from task-based characteristics to human-centred characteristics” (Xing & Marwala, 2017, p. 10). In other words, because of the dominant role of increasingly powerful artificial intelligence (AI) algorithms, it makes no sense for humans to keep competing with machines. The fourth industrial age requires skills that are not exactly those required during the third industrial age when the key driver was information technology. The new required skills are “critical thinking, people management, emotional intelligence, judgement, negotiation, cognitive flexibility, as well as knowledge” (Xing & Marwala, 2017, p. 10–11).

In 2018, Bryan Edward Penprase publishes the book chapter *The Fourth Industrial Revolution and Higher Education*, and, again, emotional intelligence is presented as the tool that can turn the challenges of the fourth industrial revolution into opportunities. The author describes the current technological revolution in the following terms:

The 4IR often is described as the result of an integration and compounding effects of multiple “exponential technologies”, such as AI, biotechnologies and nanomaterials. One example of the emerging reality within the 4IR is the development of synthetic organisms (life from DNA created within computers and bioprinted) manufactured using robotic assembly lines, where

nanomaterials provide immense improvements in the efficiency of production (Penprase, 2018, p. 220).

As this is the situation, the jobs expected to dominate in the coming decades are those arising within the fourth industrial revolution technology sectors, and in particular artificial intelligence, machine learning, robotics, nanotechnology, 3D printing, genetics and biotechnology. However, it would be a mistake to assume that the changing economic systems will only need more scientists and engineers with high IQ and strong logical skills. Indeed, “within those sectors, employers and industries are projecting that social skills that include persuasion, emotional intelligence and capacity for teaching others will be at a premium” (Penprase, 2018, p. 221).

Finally, it is worth paying some attention to *The Future of Work*, a speech given by the Governor of the Bank of England, Mark Carney, at the Central Bank of Ireland on September 14th, 2018. The sequence of the reasoning is the same we have encountered above. First of all, Carney warns that “we are on the cusp of a Fourth Industrial Revolution, which has the potential to transform fundamentally the nature of both work and commerce through advances in AI, automation and interconnectedness” (Carney, 2018, p. 3). One may notice that – at least nominally – we are on the cusp of a fourth industrial revolution since the 1940s. However, it cannot be disregarded the fact that in the new narrative machines are reaching and surpassing many human capabilities. The Governor emphasizes that, unlike past technologies, the new ones may increasingly provide reasoning, sensory perception, and intelligence. In other words, they can do what previously only workers could do.

If this is true, most current jobs will disappear. However, according to Carney, there is no reason to despair, because new jobs will arise that will require different skills. In his view, the end of work (as we know it) can be seen as an optimistic scenario. Not by chance, he says that “technological optimists believe future automation will move beyond substituting for the ‘routine-manual’ human tasks technology performed in the late 20th century to almost the entire spectrum of work” (Carney, 2018, p. 5).

So, what will humans do in the future? We already know the answer: “It may be left to people to provide ‘hearts’ – that is, tasks that require emotional intelligence, originality or social skills such as persuasion or caring for others” (Carney, 2018, p. 5).

Conclusion

As our EFPR dynamics analysis has shown, the term “fourth industrial revolution” has been used in the last 80 years – though with different meanings – to symbolize the next “big thing” on the horizon. Currently, it is associated with highly automated and smart production and distribution systems, mainly based on Artificial Intelligence, that will require either very little human workforce or a different type of human worker. The data at our disposal show that much emphasis goes on “emotional intelligence” as the key factor to keep humans in the loop. As a consequence, according to a growing number of scholars, the new challenge of educational systems in technologically advanced countries is to nurture and enhance emotional intelligence in children and adults. It is

difficult to say if scholars are just following a new scientific fashion, or if their convergent analyses are telling something significant about the new world we are entering. As it is often repeated, nobody can predict the future with certainty. But exactly for this reason, it is useful to have at least on paper more than one plan. This scenario analysis invites to craft an educational plan B based on emotional intelligence to be rapidly implemented in case the industrial system evolves in the direction indicated by the experts.

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